Title:

To swim or not to swim: An interpretation of farmed mink's motivation for a water bath.

Running headline:

Swimming water for farmed mink

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Summary

How an animal's behavioural (ethological) needs can be met is a pivotal issue in the assessment of welfare for captive animals. The value of swimming water for farmed mink is an example how scientific and societal questions relating to animal welfare can be answered. A number of studies have addressed the issue of the indispensability of swimming water for mink; however, so far with inconclusive evidence. In this paper, the results of these studies and related literature are reviewed.

First, the biological definition of need is discussed. Subsequently, attention is paid to the effects of the presence, absence and the removal of swimming water on behavioural and physiological correlates of well-being including stereotypic and anticipatory behaviour and urinary cortisol. Thereafter we discuss individual differences in the use of swimming water, the price animals pay for access to a water bath, and the effect of access to swimming water on juvenile play.

The main conclusions of the literature review are that **1)** the use of a water bath for mink is most likely related to foraging behaviour (foraging areas: land and water); **2)** absence of swimming water, without prior experience, does not lead to consistent changes in level of stereotypic behaviour, or anticipatory responses; **3)** removal of a previously experienced water bath may induce short-term stress as indicated by behavioural parameters and elevated cortisol responses; **4)** mink work hard for access to a swimming bath and running wheel in consumer demand studies. Other cage modifications such as tunnels and biting objects, may also provide environmental enrichment, if they are added to otherwise impoverished conditions; **5)** There are individual differences in the use of swimming water: these are related in part to variation in prior experience of aquatic resources.; **6)** As prior experience is important both with respect to individual use of swimming water and the response to deprivation, swimming water can not be described as biological need in the sense of a fixed requirement for survival. As swimming water appears to act as an incentive that induces its own motivation a more accurate term may be an "incentive induced or environmentally facilitated need". Given the available evidence, it is not possible to conclude whether mink that have never experienced swimming water, suffer as a consequence of its absence. However, it is possible to predict that mink with access to water have improved quality of life, due to increased behavioural opportunities, in comparison to farmed mink without access to swimming water. In practical terms, it is still open to debate whether mink should be provided with swimming water, or if alternative, less valued, but easier to install and maintain forms of environmental enrichment, should be provided in mink housing.

To clarify these issues a number of future studies would be valuable. These include; **1)** whether specific environmental cues affect motivation to swim, such as the form of drinking water delivery systems ; **2)** whether prior experience of swimming water affects its incentive value; in other words "can you miss what you never experienced?"; **3) do** behavioural parameters such as stereotypic behaviour; rebound effects and vacuum activity have any general utility in assessing

the value of absent resources; **4) what are** preferences for and the value of alternative resources which may act as substitutes for swimming water. In addition we would recommend further work investigating: relationship between access to swimming water and positive indicators of welfare such as play and/or anticipatory behaviour; the effects of preventing the performance of rewarding behaviours and deprivation of a previous experienced resource; and health and hygeine issues related to provision of a water bath. In future work, it would be desirable to present be the actual percentages of animals using a water bath during the experiment and the use of power analyses, to aid their interpretation.

Keywords: farmed mink, animal welfare, biological need, motivation, swimming water, animal housing

1. Introduction

The deprivation of behavioural or ethological needs is a key feature of poor welfare of animals kept in captivity (see Dawkins 1988; Friend, 1989; Rushen et al., 1993). Animals have a certain degree of plasticity to adapt their behavioural repertoire to environmental demands, in which case, hey can acquire new behaviours (learning), omit non-adaptive behaviours or adapt behavioural strategies to available resources. However, where behavioural plasticity is limited and the animal is equipped with pre-programmed specific behavioural strategies ("standard answers") to cope with “standard” demands of the environment to which the species has been adapted during evolution, the capacity to adapt to captive animals may be restricted (see for coping strategies: e.g. Fokkema et al., 1995; Koolhaas et al., 1999).

The role of swimming water for farmed mink has elicited much debate with respect to scientific and the societal concerns regarding animal welfare and related ethical issues associated with this agriculture activity in some European countries.Whether access to swimming water represents a behavioural need for farmed mink, thus far has not been resolved conclusively. Therefore, a concerted action of a combined set of studies was launched to attempt to resolve this issue: Is swimming water an indispensable stimulus, a conditional need, or is swimming water no need at all for farmed mink?

This paper aims to discuss the main results and conclusions of these studies (the separate full studies are published elsewhere) as well as other available literature on the meaning of swimming water for farmed mink. Attention is paid to the effects of the presence, the absence and the removal of swimming water (deprivation) on stereotypic behaviour, anticipatory activity, levels of urinary cortisol, individual differences in use of water resources, preference and consumer demand studies, and the effect of swimming water on juvenile play as a potential positive indicator of animal well being. The present paper does not address animal management issues such as the economic consequences of the introduction of swimming water on farms, the potential legislation to cover swimming water delivery in different countries, or the effect of swimming water on reproduction, pelt quality and health. Nor does this paper discuss the ethical aspects on the purpose wherefore mink is commercially bred.

The paper starts with a short summary on the concept of behavioural needs, followed by minks’ natural habitats on land and water, and the use swimming behaviour by captive mink.. Subsequently, we discuss: the development of stereotypies in farmed mink in the presence and absence of swimming water; consumer-demand tests and substitutability of alternative resources; the importance of prior experience with swimming water; anticipatory and juvenile play behaviour in the presence and absence of a water bath; and the effects of deprivation and challenges involved in the study of behavioural deprivation. Finally, we question why mink might be motivated to have swimming water, draw conclusions on the necessity of providing swimming water to farmed mink, and provide advice for future research and for farming practice.

2. Behavioural needs and reward

Behavioural needs: definitions, concepts and some characteristics

Behavioural needs or “what is indispensable to an animal”, have been described in various ways. One approach is to reflect on the wild or natural environment and suggest all elements animals that are denied in captivity can be described as lacking or deprived (Thorpe, 1965; Martin, 1979). This approach has been largely rejected by animal welfare scientist, citing the organism’s behavioural plasticity and the effects of domestication and humans’ selective breeding programs (e.g. Dawkins, 1980, 1983; Poole, 1992; Veasey et al., 1996 Price, 1999) who concluded that it would be inappropriate to assume captive animals would require the same elements in their environment as their wild conspecifics.

A more classical definition of behavioural needs can be found in “Who needs behavioural needs?” by Jensen and Toates (1993). They defined a behavioural need as a specific behavioural pattern that should be performed, irrespective of the environment, even when the physiological needs related to this essential behaviour have been met. The biological relevance or adaptive value of performance of these types of behaviours may reside in long-term benefits for the individual or its offspring (e.g. behaviours concerning reproduction, foraging and grooming). It is often assumed that the motivation to perform these essential behavioural patterns is governed by an internal motivation (e.g. Friend, 1989) and that expression of the behaviour itself may have rewarding properties, as it is unlikely that the individual is capable of assessing long term efficacy or reproductive fitness. From a proximate point of view, the involvement of some *reward* can therefore underpin the regular performance of the display (see e.g. Hernnstein, 1977; Spruijt et al., 1992, 2001). This concept of self-rewarding behaviours can be used to explain why ceratin behaviours such as exploration, foraging, grooming, still appear in the behavioural repertoires of captive animals, even when the functional benefits of their performance have been removed. Spruijt et al. (2001) more recently investigated neurobiological evidence for these rewards, based on studies of addiction and affect (e.g. Berridge, 1996; Berridge and Robinson, 1998; Panksepp, 1998; Panksepp and Burgdorf, 2003) by studying the link between neuronal structures and the phases (appetitive and consummatory) of patterns of behaviour. Spruijt and colleagues (2001) described behavioural patterns in terms of appetitive and consummatory activities, where the appetitive components have been associated with mesolimbic dopamine (e.g. Schultz, 1998, 2000; Berridge, 1996; Panksepp, 1998). Panksepp (1998) had previously characterised the appetitive components as seeking behaviour; whereas Berridge (1996) characterised this motivational phase as wanting, whilst consummatory activities were more associated with linking incentives with rewards.

Alternatively the term *behavioural priority* can be used instead of behavioural needs as introduced by Mason et al (2001) and discussed by Cooper and Albertosa (2003). The term “behavioural priority” takes into account a hierarchy of requirements, in line with different motivations, whereby the need to satisfy these particular motivations depends on internal and external circumstances, as well as previous experiences and current circumstances and takes into account the motivational and emotional state of the particular individual (see Cooper and Albertosa, 2003). Hence, context is an important factor on describing behavioural needs and it may even critically address practical issues of derived from precise definitions on behavioural needs (Jensen and Toates, 1993). For the purposes of this paper we shall use Jensen and Toates concept of behavioural needs as the conceptual framework to discuss the findings of empirical studies, as this has value to predicting the features we would expect of a behavioural need, and use the concept of behavioural priorities when assessing the relative importance of alternative resources as this has more practical value in on farm welfare assessment than absolute,definitions of need.

Several characteristics of behavioural needs are mentioned in the literature. In short, some main characteristics of behavioural needs are: (1) Absence of stimuli that are indispensable for essential activities, or denying the actual performance of essential behavioural patterns, can induce a state of chronic stress, resulting into physiological and/or behavioural pathology (e.g. Hughes, 1980; Friend, 1989; van Liere and Wiepkema, 1992; Broom and Johnson, 1993; Jensen and Toates, 1993; Vestergaard et al., 1997); (2) The behaviour can be performed without the presence of eliciting cues (primarily internally motivated; e.g. Friend, 1989); (3) The behaviour is performed at a higher rate when the animal is first allowed to perform the behaviour after a period of deprivation (“damming-up”: Friend, 1989 or rebound effects Vestergaard 1982); (4) The presence of vacuum activities (Hughes and Duncan, 1988), i.e. animals deprived of an opportunity to perform an action might eventually show it even in the absence of the required stimuli: laying hens “dust bath” even when the dust bathing substrate is absent (see e.g. Widowski and Duncan, 2000); (5) The display itself has rewarding properties, involving meso-limbic dopamine and opioids (see e.g. Panksepp, 1998; Berridge, 1996; Spruijt et al., 2001). For a number of behaviours one could say that the display results in release of endorphins (opiate neuropeptide) which reinforce their occurrence: for example, social behaviour (van Ree et al, 1999), play (VanderSchuren, 1995a, b), and grooming (Spruijt et al., 1992) are facilitated by opioids and their occurance can decrease following treatment with an opiate antagonist.

Two issues remain clear in the discussion of essential needs. Firstly, it is not possible to give precise standards on timing, duration and frequency that a particular ‘indispensable’ behavioural pattern should be performed by an individual member of the species, as this depends on the context (see Jensen and Toates, 1993; Cooper and Albertosa, 2003). As behavioural needs involve species specific patterns, the only sure statement to be made is that it seems evident that these particular patterns are performed by all individuals of that species, e.g. ingestion of nutrients, thus searching for food is essential to all animals (essential for survival: see Poole, 1992), and can also be seen in captivity if the opportunity is there (jc note, not sure I agree with this statement). Secondly, it is debateable how many of the aforementioned characteristics should be demonstrated before one should entitle a pattern as ‘indispensable’. Alternatively, does the occurrence of just one of these characteristics indicate we should treat an activity as a behavioural need? Although an interesting topic for future scientific discussions, this paper does not aim to use this listing in this particular way. The list only involves some important issues that may be helpful to elucidate the discussion on minks’ motivation to a swimming bath in more detail.

These above-mentioned features can be found in many other discussions on behavioural needs and/or behavioural priorities in other species. Notable examples include the dust bathing behaviour of chickens (e.g. Vestergaard, 1980, 1982; ; Nicol and Guilford, 1991; Vestergaard et al., 1997, 1999; van Liere and Wiepkema, 1992; Petherick et al., 1995; Johnsen and Vestergaard, 1996; Lindberg and Nicol, 1997; Duncan et al., 1998; Widowski and Duncan, 2000; Nicol et al., 2001), nesting and pre-laying behaviour in the laying hen (e.g. Cooper and Appleby, 1995, 1996, 1997) and the rooting of pigs (e.g. Lawrence and Terlouw, 1993; Horrell et al., 2001; Studnitz and Jensen, 2002; Tuyttens, 2005).

Compensatory actions

Where the necessary elicting stimuli for the display of an important behaviour are absent in the animals’ environment, abnormal behaviours have been described (Fox, 1968). These include stereotypic behaviour in the absence of rooting substrate for pigs (e.g. Lawrence and Terlouw, 1993); hyperactivity and stereotypic behaviour in canids and polar bears when opportunities are absent to explore (e.g. Wechsler, 1991; Clubb and Mason, 2003). One hypothesis that links behavioural deprivation and stereotypic behaviours is the involvement of reward systems that may compensate for inability to interact with functional substrates or meet relevant behavioural endpoints (e.g. Cronin et al., 1985, 1986; Cabib, 1993; Cabib and Puglisi-Allegra, 1996, Spruijt et al., 2001). The compensation hypothesis and its underlying mechanism are demonstrated on studies on play (e.g. van der Schuren et al., 1995a, b; 1997): play deprived animals compensate by enhanced sucrose intake and increased bodyweight. Morphine counteracted this compensatory sucrose intake, which can be explained that the absence of play-induced release of endorphins is compensated by morphine.

In this compensation hypothesis, the display of compensatory behaviours may be elicited if reward systems are sensitised by stress (for sensitisation of reward systems in case of stress: see

Piazza et al., 1990). Self rewarding behaviours, which still can be performed, are likely candidates to compensate for the "lack of reward" and may even be performed in a compulsive way. It is especially these kinds of behaviours, (e.g. perseverance of intentional activities such as foraging patterns and self directed activities such as grooming), that appear to be prone to develop into stereotypic behaviours (e.g. Spruijt et al., 1992; Rushen et al., 1993; Spruijt et al., 2001), in case of frustration (e.g. Duncan and Wood-Gush, 1972; Mason, 1991), lack of stimulation (e.g. Mason, 1991; Broom and Johnson, 1993) and other chronic stressful conditions (e.g. Cronin and Wiepkema, 1984; Cronin et al., 1985; Mason, 1991; Broom and Johnson, 1993; Rushen et al., 1993). Theoretically, this might be the background of some behavioural pathology.

Individual variation and prior experience

The consequences of individual experience on the performance of particularly motivated behavioural patterns, and the need to perform these particular patterns on long term, is an area in discussions on behavioural needs. Behaviours that have to be performed even if the animal has never had experience of eliciting stimuli in the appropriate context (and have been described as motivated mainly by internal mechanisms patterns, Hughes, 1980; Hughes and Duncan, 1981), should appear different from an induced pattern of activity resulting from prior experience. The latter might be referred to as an “incentive induced need” or “incentive induced motivation” (as derived from drug addiction literature: e.g. van Ree et al., 1999), and may not be classified as a behavioural need (who has said this, is it an opinion we are making, in which case again, not sure I 100% agree, the arguments below make sence, BUT, in much the same way that it is challenging to absolutely demonstrate no role of experience in claiming an activity is “innate”, I think its challenging to absolutely demonstrate an activity is induced or non-induced). Compared to activities that are not incentive-induced, this leaves us the same theoretical question: how much can a particular individual subject suffer if denied from its “incentive induced need”? In practice, however, an incentive induced motivation may never have consequences for the animal if never provided. Thus, in view of animal welfare in practice the question still is: which behaviours form an indispensable part of the animal’s repertoire and which are induced by prior experience and can be missed in captivity if the animal has no such prior experience?

Although an elaborated overview on behavioural needs is not within the scope of the present paper, nevertheless, it is expected that classification is at least based on some of the above-mentioned characteristics and principles__ they are used as the general framework for further discussion in this paper.

3. Minks’ natural habitats: land and water

For the largest part of the year, mink live solitarily in territories along watersides, such as rivers, lakes and coast sites (Gerell, 1970; Birks, 1981; Dunstone, 1993) with more than one den side (Birks and Linn, 1982). Mink show great flexibility in prey species. Seasonal fluctuations in availability of prey, i.e. abundance and ease of capture, necessitate mink to have a flexible hunting strategy on land and in the water (Dunstone, 1993). Dunstone (1993, p. 63) mentioned two likely reasons why wild mink may choose to enter the water in search of prey: 1) either terrestrial prey becomes more difficult to capture than aquatic prey, or 2) there is an increase in the ease of exploitation of aquatic prey: e.g. decreased ambient temperature decreases the escape reactivity of the poikilothermic fish prey (Gerell, 1967).

Mink's adaptations to under-water hunting are not optimal as compared to the otter or more strictly aquatic animals (e.g. seals), but are appropriate and efficient: their fore- and hind feet are inter-digitally webbed, they have a semi-water resistant pelt (mean pelt density from mid-back region: 780 hairs/cm^2, Dunstone, 1979), and they have some adaptation of the anatomy of the eyes to overcome the refractive problems involving underwater vision (Sinclair et al., 1974; Dunstone, 1993, p. 51). Results on respiratory adaptations to diving, like bradycardia, are not conclusive in the literature, but Dunstone (1993, p. 43) concluded that minks' dives, with a recorded maximum length up until 30 seconds, are aerobic, i.e. carried out using the body's normal oxygen reserves. In addition to aquatic adaptations, mink can also run fast and see well on land, and so, appears to be optimally equipped to apply for a maximum of profits in two kinds of hunting habitats (see Dunstone, 1978).

Some feral populations of American mink are known in Europe (e.g. Dunstone and Ireland, 1989; Ireland, 1990; Halliwell and MacDonald, 1996) and are described to be responsible for the decline of many endemic species and sea bird colonies (e.g. Bonesi et al., 2006). Recently, a decline was observed of the feral mink population in England, which was explained by an interspecific competition of *Mustela vison* with the native otter population (Bonesi et al., 2006).

4. Swimming of mink in captivity

In a semi-natural cage, juvenile mink were observed to start entering the water pool at the age of about seven weeks (Kuby, 1982). Poole and Dunstone (1976) mentioned that their experimental subjects, hand raised ranch-bred mink, had to be given experience of water at an early age or they never became proficient swimmers when adult. In their studies they always trained their new batch of mink kits by encouraging them to swim. Interestingly, de Jonge and Leipoldt (1994) observed that the water bath was more attractive around feeding times. In general, they described mink's behaviour towards the water bath as "hesitating": i.e. the subjects stopped in front of the waterside and even sat along the water for long periods before entering the water; sometimes they accidentally fell into the water, but than the subjects always left the water quickly (*cf* de

Jonge and Leipoldt, 1994, p. 142). In contrast to “hesitating”, Kuby (1982, p. 56-57) mentioned mink’s swimming an “innate” pattern, and described the first swimming performance of one of his mink pups “nor looking clumsy neither unsure”.

The aquatic hunting of mink is thoroughly described by Poole and Dunstone (1976) based on series of laboratory observations and experiments. Most striking was their observation that fishes were generally detected by their mink subjects before they entered the water by the head dip, whereby mink typically peers its head under water while having a continue grip on land with their hind feet; only when prey is localised they dive into the water (Dunstone, 1978; see Korhonen et al., 2003 for recent observations of head dipping on farms). In the water tank, mink showed surface swimming as well as underwater swimming, whereas surface swimming was found to be the slowest mode of progression (38 cm/s, Dunstone, 1979). Mohaibes et al. (2002, 2003) studied the behaviour of farmed mink also in the winter period when the water of the water bath was partially or totally frozen: the partially frozen ice offered the subjects novel challenges and the mink started to creep into the cave-like holes in the ice, to dig the sludge and to manipulate parts of ice (Mohaibes et al., 2003).

Addressing the frequency of mink’s water-use under farmed conditions, Skovgaard et al. (1997a, b), Hansen and Jeppesen (2001b), Mohaibes et al. (2001, 2002, 2003) showed clear individual differences in the use of the water bath. Some animals never entered the water: e.g. in the study of Skovgaard et al. (1997b) fourteen subjects of a total of forty animals provided with water never entered the bath; in the study of Hansen and Jeppesen (2001b) one of a total of eleven subjects, of which the behaviour was recorded for 24 hours, did not swim.

Vinke et al. (2005) studied twenty-eight wild-coloured juvenile mink reared in the presence of a water bath and observed that the juveniles spent a mean percentage of total observations of 1.4 in or around the water bath, whereby the exploration of the bath and the head dip were observed most frequently. This percentage was identical to the percentage for adult mink as observed by Skovgaard et al. (1997b: 1.4% of the total scans, in 40 subjects provided with a water bath). In a pilot, de Jonge and Leipoldt (1994) observed seven adult females in cages with a water bath from 7 hours until 1 hour before feeding time: they found that the females spent their time inside the water in a range of 0-11% (of the total observations), and around the water bath in a range of 2-27%, whereby specifically one female scored in the higher ranges. Additionally, they found that the subjects increased their time in and around the water bath before feeding time.

Mohaibes et al. (2003) observed forty-five scan-glow female mink and found mean percentages of total observations of swimming of 0.35% (± 0.59 S.D; N=14) in July and 0.60% ± (0.57 S.D; N=14) in September-October. The percentage of observations in the swimming pool when the pools were partially frozen was 9.5% (± 5.0 S.D.; N=14). Hansen and Jeppesen (2001b) reported that the number of swims of eleven mink during 24 hours ranged from 0-177; and that the durations of swimming bouts varied from 2 to 55 seconds.

Hansen and Jeppesen (2000a, b) described an experimental design with three connected cages, having a water bath or an empty cage in the middle: the experimental subjects always had to pass the water bath or the empty cage to reach the food location and/or the nest box, or they could choose an alternative "dry-route" as created by a tunnel above the water bath. If the access to the opposite cages was only possible through the water bath, the animals appeared to be slower in reaching food and crossed less frequently between the food and the nest box, as compared to situations that they either could use the tunnel or had a dry middle cage. In addition, animals scratched more at the blocked tunnel access if the only available route was through the water, than when they could go through a dry middle cage. The latter may indicate that the mink preferred to use the alternative dry tunnel route to the food. The results suggest that under some circumstances or for some individuals, water can act as a barrier. Although these kinds of designs can yield further insight into the incentive value of water baths, the papers did not report the frequency of water- and tunnel passages in more detail and gave no insight whether the dry route might also be the faster route.

The frequencies of 'swimming' and 'around the water bath', may give some insight into the contribution of this particular patterns in farmed minks' time budget, nevertheless, they are not necessarily indicative for the value of swimming water for farmed mink: not all essential behavioural patterns should be expressed continuously in high frequencies to become classified as indispensable. This highly depends on other factors as well, e.g. sexes, age, observation season. On the other hand, the topic of the observed individual variation, with some individuals never entering the bath, is worthwhile to be addressed in the discussion, as a behavioural need *pur sang* is expected to be performed by all individuals because it concerns a species specific motivation and / or pattern.

5. The presence or absence of swimming water and effects on stereotypical behaviour and some other welfare indicators

Stereotypies in the presence and absence of a water bath

One of the best described behavioural pathologies in mink is the occurrence and development of stereotypies (see point [1] of the afore-mentioned characteristics of behavioural needs). In some studies the occurrence of minks' stereotypies was observed in the presence and absence of a water bath.

De Jonge and Leipoldt (1994) concluded that the availability of swimming water did not significantly reduce stereotypical behaviours in adult mink (N=7 females). Skovgaard et al. (1997a, b) studied adult mink in the absence and presence of swimming water. They concluded that the free access to swimming water had no significant effects on reproduction level (Skovgaard et al, 1997a; N= 64; females and males) or on stereotypies (Skovgaard et al., 1997b;

N= 64; females and males). Hansen and Jeppesen (2001a) concluded that swimming water may not be classified as a behavioural need for mink, because the introduction of water was not followed by a reduction in stereotypical behaviour. Hansen (1998) reported an increased activity when the water was refreshed in the experimental water trays, “like that which is seen just before feeding time” (Hansen, 1990, 1998), but he found no effects on reproduction level or immune responses. Some studies reported that mink subjects were performing stereotypical patterns inside or in the presence of a water bath (Skovgaard et al., 1997a; Mohaibes et al., 2002, 2003; Vinke, 2004). Vinke et al. (2006) found no differences in anticipatory or in stereotypical behaviour in 4 months respectively 10 months old mink, in the presence and absence of swimming water (N= 56 females in total; Water present *vs* absent: 24 subjects per group). Mohaibes et al. (2002, 2003) investigated the effects of a swimming bath on stereotypical behaviour: they found that mink with baths had less frequent stereotypic behaviour than mink without baths. This difference was statistically significant in Mohaibes et al. (2002), although only a tendency was found in Mohaibes et al. (2003).

In conclusion, it appears that in most studies the presence of swimming water does not significantly influence the levels of stereotypies and some other used parameters (e.g. reproduction, immune response, anticipatory behaviour). A critical note must be mentioned towards the age of the experimental subjects in all studies and the consideration that stereotypical behaviour can established over age (e.g. Mason, 1991; Mason, 1993a, b): most aforementioned studies are carried out with adult mink. Comprehensibly, a study with subjects that have already established a stereotypy is different from a study that starts with juveniles that are free of stereotypies. Without a baseline study for the level of stereotypical behaviour at the beginning of the experiment, the interpretation on the effects of swimming water on the development of stereotypical behaviour is hard.

The presence of swimming water may induce play behaviour

Vinke et al. (2005) demonstrated increased display of play of juvenile mink on the cage floor in the presence of swimming water. No significant relation could be found between juvenile play and stereotypical behaviour in adulthood. Nevertheless, the observation of play can be of interest for welfare assessment, as play is not performed under stressful conditions (Lawrence, 1987; Broom and Johnson, 1993). In rats, it has been shown that juvenile play is necessary for coping with social stress in adulthood (van den Berg, 1999; van den Berg et al., 1999a, b; von Frijtag, 2001; von Frijtag et al., 2002). Play is a typical example of a behavioural pattern with long-term adaptive value, but without high priority at a short term. Additionally, play involves opioids (VanderSchuren et al., 1995a, b). Play, therefore, has been proposed as a positive indicator of animal welfare. Thus, indirectly, stimuli such as water, eliciting play may enhance the animal’s coping capacity and contribute to the animals’ well being by their rewarding properties of the mere display.

6. What is swimming water worth to mink, and can it be substituted?

As discussed before, a water bath may mean either a reward or a barrier for some individual mink. The question still emerges: is swimming water merely enriching, or is its presence indispensable for farmed mink? Methods to assess the animal's appraisal of its situation are: (i) assessing the price the animal is willing to pay for access as addressed by consumer-demand studies (e.g. Dawkins, 1983; 1990; Mason et al., 1997, 1999; Cooper and Mason, 1997, 2000) and (ii) assessing the sensitivity of the reward systems as addressed by studies measuring the intensity of anticipatory behaviour (e.g. von Frijtag et al., 2000, 2001; Spruijt et al., 2001; van der Harst, 2003; van der Harst et al., 2003, Vinke et al., 2004b, 2006, Dudink et al., 2006). Theoretically, anticipatory behaviour preceding an incentive can be induced without previous experience of swimming water. Thus, this method can be applied to assess and compare the sensitivity of the reward system of mink in the presence, absence and after deprivation of a swimming bath, and so, may give some insight into the effects of experience on swimming motivation ("can you miss what you do not know?"). Consumer demand tests are used to assess how the animal values different resources and are especially based on two techniques borrowed from human economics: 1) the measurement of elasticity of demand and 2) the measurement of income elasticity (Mason et al., 1997). It is assumed that the resources that are valued highly by the animal are inelastic: the animal will invest much energy, e.g. press more weight, to get access to this resource. In human society, the market of bread or rice as basic foods, are called inelastic as people will remain to buy it, whatever the price. On the contrary, all kinds of luxury products like cars and audios can be seen as elastic.

In a consumer-demand set-up of Mason and colleagues (2001), eight male and eight female mink could choose to "pay costs" (i.e. push doors with variable weights: 0, 0.25, 0.5, 0.75. 1 or 1.12 kg for seven successive days) for either a water bath, an alternative nest site, novel objects, a raised platform, toys, a tunnel or an empty cage. They found that farmed mink, with the exception to food, rated the water bath as the most valuable resource, as it attracted the greatest total expenditure and the highest reservation price, greatest consumer surplus measures of utility, and the most inelastic demand (Mason et al., 2001, p. 35).

In a subsequent study, the direct influence of stimuli eliciting the motivation to swim was excluded ("Is out of sight out of mind?"): Warburton and Mason (2003) studied the hierarchy of four test resources, (i.e. food, water bath, social contact and toy) in two ways: 1) "cues treatment": resource cues were present when preference was expressed and 2) "no cues treatment": resource cues were distant and (visually) screened at the choice point (N= 6 in both treatments). They reported that food was preferred in both treatments, but motivation for toys and possibly also unpredictable social contact declined in the "no cue treatment". They tentatively suggested that the visibility of water might have little effect on the motivation for the water bath. Thus, water cues do not elicit the need for it, although this does not address the issue of experience. Previous findings on the preference on resources of farmed mink in the study of Mason et al. (2001) were most closely replicated by the findings from the "No Cues treatment" in the study of Warburton and Mason (2003), which might appear paradoxical in the sense of that in the first study the cues were available at the point of preference measurement. Differences between the two separate studies might be explained by the small sample size, differences in the used mink populations, used test resources and effects of habituation.

Hansen and Jensen (2006a, b) also used a consumer-demand design to assess the rewarding properties of a water bath and a running wheel either separately, in a situation whereby both resources were present at the same time, and in a situation whereby one of the experimental resources was "free" (no pay) and the alternative was not. The subjects in this design could pay costs by pressing a lever on fixed ratio schedules varying from 5 up to a level of 60 times pressing for access to the experimental resource. There were no differences between the elasticity of the demand for swimming water and a running wheel, indicating that mink valued these two types of cage enrichment similarly. However, mink needed more rewards to lower the motivation for locomotive activity in the running wheel (higher intensity of the curve) than to lower the motivation for exploration in the water. Each supposed occupational enrichment has to be evaluated in relation to the motivation behind the use of the actual resource, but in the present experiment the running wheel had a higher occupational value for the mink than the water bath.

The simultaneous presence of both resources did not affect the demand for either running wheel or swimming water in the study of Hansen and Jensen (2006a, b). Furthermore, with free access to either of them mink did not increase their use of the running wheel as the price of swimming water increased, or their use of swimming water as the price of running wheel increased. Therefore, the two resources did not appear to be a substitute for each other. Both a running wheel and swimming water were valued higher than access to an empty water box. Mink mainly used the running wheel during their normal activity periods, whereas, the swimming water was primarily used in the morning when the water box was refilled and the mink were fed. Based on the lack of substitutability between the two resources and the different diurnal patterns, it was suggested that different motivations underlie the two test resources.

7. The effects of prior experience of a water bath and deprivation on some behavioural and physiological parameters

Prior experience of a water bath might influence an animal's motivation to use a bath. In the literature, we found some studies addressing the effects of deprivation of a previously experienced water bath and deprivation.

In the studies of Mohaibes et al. (2002, 2003) mink with a swimming bath experience for several weeks were deprived of their baths for two weeks by blocking the access to the bath. In both studies the average values for the amount of stereotypies were higher during than before or after the deprivation, but it was not reported whether these differences were statistically significant. Furthermore, addressing the amount of stereotypies during the deprivation in the bath group, the mink did not differ significantly from two control groups deprived of access to an extra cage (of the size of the bath) or deprived of nothing (Mohaibes et al., 2003). During the deprivation period all three groups had available standard mink cages with standard nest boxes.

In another study, conditions with a water bath and without a water bath (standard housing) did not change the level mink's anticipatory behaviour preceding a food reward. Neither was the level of anticipatory behaviour significantly affected after a two-week deprivation of swimming water whereby the water was removed from the bath (Vinke, 2004; Vinke et al., 2006: water-group and control-group: 2x14 subjects, each split into: Cue-US treatment n= 7 *vs* Cue-no CS treatment, n=7 as a control for anticipation). In rats, it has been shown that enrichment reduces anticipatory behaviour preceding a food reward and that isolation stress increased this behaviour (van der Harst, 2003). Therefore, the result obtained in mink might suggest that mink valued swimming water and the empty bath in a similar way, though larger samples would be needed in the study of Vinke et al. (2006) to rule out type II errors.

Addressing physiological parameters, Mason et al. (2001) found higher increased levels of the stress hormone cortisol in urine samples, 24 hours after blocking the access to a swimming bath. Compared to baseline values and to other situations with blocked incentives, the increased cortisol levels indicate that the value of swimming water might be higher than the value of other enriching objects in the test with the exception of food, which like-wise increased the level of urinary cortisol. In a more recent study, Warburton and Mason (2006, p. 77) found that preventing bath-access significant induced access attempts ("scrabbling"), although they found no significant corticosteroid response. In addition, Korhonen et al. (2003) found increased levels of urinary cortisol-creatinine and corticosterone-creatinine ratios after blocking access to swimming water: the adrenocortical response was highest during the second week of deprivation and decreased thereafter. These results indicate on a short-term stress (24 hours-two weeks) after a period of deprivation by blocking.

An alternative explanation of increased levels of cortisol might be found in the fact that mink prefer to drink from the water bath (Hansen and Jeppesen, 2003) instead of their water bottle or drink nipple. Consequently, mink that are denied access to the water bath may drink less for a period which may also enhance the cortisol levels (Tauson, 1999). A recent study of Warburton and Mason (2006, p. 77) found that the cortisol levels were not changed significantly when preventing the access to the bath. No information was available on the level of water consumption.

Referring to some other previously mentioned characteristics of behavioural needs, the study of Korhonen et al. (2003) reported that the deprivation of swimming water did not alter the occurrence of stereotypical behaviour and that no *vacuum activities* (point 5) have been reported in mink in relation to swimming water. The expression of vacuum activities in relation to swimming water, in whatever form either related or not to e.g. specific stereotypical patterns, remain unclear in the literature. The same can be concluded for rebound effects: rebound effects (point 4) after a period of deprivation have hardly been described in the studies. Korhonen et al. (2003) reported no rebound responses in behaviours such as swimming, head dipping or staying on the jetty after the deprivation of swimming water was discontinued. A study of Cooper and Mason (2000, p. 147) reported a drop in the number of compartment visits combined with more intensive interactions with the swimming pool, i.e. more bouts of swimming were performed per visit, when entry prices increased. More intense interactions with the resource once the cost has been overcome might point to a kind of rebound effect, but this is in this case difficult to interpret.

Blockade and removal of a swimming bath: deprivation dilemma?

Korhonen et al. (2003) reported a tendency to an increased amount of biting/scratching the cage as a result of deprivation (i.e. blocking the entry), which suggests a general increase of restlessness. Furthermore, removing the water bath out of sight or removing the water and leaving an empty bath, resulted into increased levels of stereotypical behaviour, tail biting and cortisol levels in the blocking-treated subjects (Mason et al., 2001; Korhonen et al., 2003; Vinke, 2004). It should be considered that the blockade of an entry door that an animal had priory access to, might be stressful anyhow whatever is behind that door, e.g. swimming water, nest boxes, space (Hansen and Jeppesen, 2000a, b; see for a discussion Vinke, 2004). The removal of the whole bath from the cage preferably out of sight of the animal, therefore, might be a better experimental design for deprivation studies. Finally, it should be noted that deprivation studies always imply that animals have been in contact with swimming water, and thus, that the results might indicate on pure incentive-induced motivations.

In conclusion, deprivation of swimming water by blocking significantly influences some physiological parameters on adrenocortical responses, indicating on a higher level of stress at least on the short term. The way animals are deprived of a test incentive, blocking *vs* removal, is a point of discussion and should be elucidated in future studies. So far, prior experiences of swimming water seem to have little effect on stereotypical behaviour and anticipatory behaviour. The effects of experience should be elucidated in more detail.

8. Why mink might be motivated to have swimming water?

As the meaning of swimming water for farmed mink can be variable, different underlying motivations of the use of a water bath should be taken into account: does mink use a water bath for thermoregulation, as an easy drinking site, additional space (in most studies represented by empty baths), or as an exploration and foraging opportunity? Hansen and Jeppesen (2003) concluded that swimming water is not used as a thermoregulatory mechanism by mink, as their experimental subjects did not show increased levels of swimming at high temperatures. Based on the level of the water emerged from the basin, Vinke et al. (2004a) found that the mink used the water bath considerably less during high ambient temperatures which was the consequence of a general decrease of all activities. This is in line with the prior study of Hansen and Jeppesen (2003). The topic of easy drinking was studied by Mason et al. (1999): in a consumer-demand experiment: mink chose for a water bath in order to drink and swim. To exclude the swimming and drinking motivation, a water bowl was provided for free for “easy drinkable water”: the subjects still worked for swimming. These findings were affirmed by a more recent study of Warburton and Mason (2006, p. 77). Mason et al. (2001) also controlled for the value of additional space and exploration objects but found lower preferences for these choices than for the access to a water bath.

Although not totally elucidated, the meaning of a water bath for mink seems most likely related to foraging behaviour: on land (running, exploring sides) or in the water (exploring, head dipping, swimming) (Hansen and Jensen, 2006a, b). The observation that the swimming bath seemed especially attractive around feeding times (e.g. de Jonge and Leipoldt, 1994) suggests that a water site may stimulate exploration to or into the water as a part of appetitive feeding behaviour. Though in other species, the impossibility to display adequate foraging behaviour is mentioned as a main cause of the development of stereotypical behaviour in captive animals (e.g. pigs: Terlouw et al., 1991; Mason and Mendl, 1997), this seems not unequivocally the case in mink. Hypothetically, in line with mink’s naturally opportunistic lifestyle in a combined habitat of land and water (frozen or unfrozen), it can be expected that farmed mink might be able to cope with different situations in an environment providing enough alternative stimuli allowing the performance of one of its strategies.

9. General comments on the available studies and data and evaluation of methods

Before elucidating final conclusions, some general comments on the available studies and data addressing the topic on the importance of swimming water for farmed mink are addressed in more detail. Table 1 systematically overviews and summarizes some quality parameters as available in the presented papers (e.g. the water bath measures, water hygiene, sample sizes in the experiment, percentage of subjects using the bath, colour type used, age and sex of the subjects, observation time and period).

[about here table 1]

Comments on some quality parameters in the available studies

Focussing on farmed minks' appraisal of swimming baths in particular, it should be noted that a limited number of studies is available. In table 1, it can be seen that most studies used the colour type wild and adult female mink, but not all studies. Also within studies the experimental populations could include some subgroups (see the comments in the column *sample size*, table 1). In some studies it was not always clear how the different subgroups (e.g. male *vs* female; age) contributed to the presented results. Age of the subjects did vary between the studies, which makes a comparison between the papers rather difficult. However, some studies especially aimed to collect information on long term, and therefore followed the same subjects from juvenile until adulthood, which gives important additional information on the development of behavioural and physiological pathology in the presence and absence of a swimming bath.

Information on the used breeds or the origin of breeds in the papers, mostly involved no further details except for the farm the minks were bred. Differences in breeds quite probably account for less standardisation in farmed mink research, but standard breeds such as known in laboratory research in rats and mice are not available for farmed mink. This situation, however, does not differ from other applied studies on other farm animal species.

A lot of the presented papers involved studies that include 24h video registrations. During daily observations, the animals were observed on randomised reversal schemes. Especially the 24h observations are very valuable to have a clear insight into the bath-use of farmed mink. In most studies, the behavioural observations were conducted using a scan sampling and/or a focal animal sampling method, which mostly seems the most reliable method to answer the research question(s) as mentioned in the paper and the given research possibilities. Consumer-demand and anticipation tests used other specific parameters which are based on the literature of previous research in mink or also other species.

Addressing the season of observations, the available papers cover all months in the year. Studies concerning the juvenile behaviour were around June-August which is conform the normal development of mink. Some researches specifically aimed a long term study and covered a whole year or more. Most studies, therefore, are rather complementally than comparable.

Bath designs and measures may vary in all the available studies. Although ''the adequate'' measure is always discussable, most studies used a bath with a length of more than one meter and a water depth of at least 15 cm. In all studies the water bath was free accessible except for the special experiments, of course, like the consumer demands and the studies wherein the subjects were deprived of their water bath. In all studies the water was cleaned regularly. Differences in hygiene and so the attractiveness of the water bath in the different studies, therefore, appears not a point of discussion though none of the studies appointed the quality of their swimming water in their study precisely. Surprisingly, as all studies aimed to give insight on farmed mink water bath-use, most papers do not give a precise insight into the exact number of animals that actually used the water bath during the study (column: # subj. using bath [%], table 1).

Another topic that should be noted is that the sample sizes in some studies might be too small to find significances on particular behavioural patterns or parameters, thus, type II errors might be an alternative explanation for non significant results. Type II errors as an alternative explanation for the finding of non significant results, might play a role in the studies of Warburton and Mason (2003) and Vinke et al. (2006). **[about here table 2]**

Some specific points of discussion on the results in the available studies

Addressing all available studies, no clear differences in the occurrence of tail biting, stereotypical and anticipatory behaviour between subjects housed in the presence (water-experienced subjects) or absence (water-naive subjects) of a water bath could be demonstrated. Stereotypical behaviour could still be observed in the presence of a water bath (e.g. Skovgaard et al., 1997b; Vinke, 2004), which suggests that the provision of a water bath is not enough to meet all minks' needs in an otherwise barren environment.

In deprivation experiments, blocking the access to a previously experienced water bath might be stressful for farmed mink as shown by increased levels of stereotypical behaviour, tail biting (Korhonen et al., 2003; Vinke, 2004) and indications are found that deprivation of a prior experienced water bath significantly increased the levels of cortisol, which might indicate increased stress at least on a short-term (i.e. < 2 weeks) in the blocking-treatment (Mason et al., 2001; Korhonen et al., 2003). The question remains whether a blockade of a previously open entry-door might be frustrating under all kinds of circumstances, whatever is behind the door? Future studies might elucidate this issue in more detail.

In case of studies that observe the presence of stereotypical behaviour under farmed conditions, which is a quite commonly used parameter in welfare studies, it can be questioned whether this behavioural parameter is useful to study the effects of the presence of a water bath (see for a elaborated discussion on the reliability of stereotypies as welfare indicators: Mason and Latham, 2004)? This might be of special importance in mink considering the fact that effects might be 'overshadowed' by the effects of other management factors in mink farming. Such a prominent influencing factor might be the food management and food delivery in farmed mink, e.g. food deprivation in the winter (see e.g. Bildsøe et al., 1991; Mason, 1991; Nimon and Broom, 1999). None of the available papers did address the used food regimes in detail, and it still can be quested how food regimes may influence the results on stereotypies during winter. Another topic addressing the stereotypy parameter, and which is often unclear in the papers, is the level of stereotypies in the experimental populations at the start of the study. Preferably one should start with a non stereotyping population.

Addressing the topics on preference, resource value and play behaviour, swimming water possibly has enriching and rewarding properties for mink as it facilitates exploration shortly (more environmental variability and choices), it may induce play behaviour in juveniles and mink is willing to pay high prices (invest energy) to have access to swimming water in consumer-demand experiments. Referring to the results of the studies of e.g. Hansen and Jeppesen (2000b, 2001a, b) it should be noted that a water bath might be a barrier for some individuals; at least we have to consider that individual differences in the appraisal of a water bath may exist. Consumer-demand tests showed that mink is willing to invest energy for access to food and a swimming bath (Mason et al., 2001), and for access to a running wheel (Hansen and Jensen, 2006a, b), or to a lesser extent, for access to other diverse enrichments (e.g. Mason et al., 2001). In the study of Hansen and Jensen (2006a, b), the experimental mink used the running wheel more than the swimming bath, whereas, the study of Mason et al. (2001) showed that mink preferred the swimming bath more compared to other requirements, i.e. alternative nest site, novel objects, raised platform, toys, tunnel and empty cage. The non substitutability of the running wheel and the swimming bath indicates on different underlying motivations to both resources, which might suggest that the importance of each condition for farmed mink should be considered separately.

Rewarding properties of behavioural patterns such as eating, drinking, social contact in social species and unnatural addictive behaviours are characterized by liking and wanting aspects (Berridge, 1996; Berridge and Robinson, 1998). Wanting increases in case of deprivation, and probably underlies vacuum activities, anticipatory behaviour and rebound effects. In the literature, wanting is described to be related to an enhanced sensitivity to reward (Berridge, 1996; Berridge and Robinson, 1998). This enhanced sensitivity of the reward system in the absence of a water bath was not demonstrated in the study of Vinke et al. (2006). However, other studies showed that a subsequent blockade appeared frustrating for mink that had previous contact with swimming water (Mason et al., 2001; Korhonen et al., 2003; Mohaibes et al., 2002, 2003; Vinke, 2004). Apparently, experience does induce wanting which suggest that access to water is an incentive-induced motivation. Access to water for farmed mink might be comparable to running in a running wheel for rodents (running wheel behaviour has been associated with incentive-induced behaviour: e.g. Belke, 1996; Lett et al., 2002; Werme et al., 2002; Rhodes et al., 2003; Vargas-Perez et al., 2003): once they have experienced it, they like it.

10. Summarizing conclusions

Generally, the scientific discussion on behaviour needs, or preferably behavioural priorities, of animals, is still an ongoing process. In the present review paper, it was chosen to elucidate some topics that might be of importance in the discussion on behavioural needs, and that might be fruitful in the discussion on the interpretation of farmed minks' motivation for a water bath. This paper, therefore, addressed some physiological and behavioural indicators on welfare, and discussed the topic of internally motivation and rewarding properties of behavioural displays, rebound effects and vacuum activities, preferences for, and the value of resources, effects of preventing the performance of (rewarding) behaviours and prior experience, substitutability of alternative resources and a 'positive indicator' of welfare, i.e. play behaviour.

The present mink studies as reviewed in this paper appear a useful source to give insight into minks' motivation for a swimming bath, but are rather complementally than comparable. Hence, each study contributes to unravel the question on farmed mink's motivation for a water bath. In short, the general main conclusions are:

1) Although not total conclusively, the meaning of a water bath for mink is most likely related to foraging behaviour (foraging areas: land and water).

2) The absence of swimming water, without prior experience, causes no consistent significant alterations in levels of abnormal behaviour indicative for chronic stress, or into increased levels of anticipatory reactivity.

3) The deprivation of a previously experienced water bath may induce short-term stress as indicated by enhanced levels of behavioural parameters ('scratching' and 'scrabbling': Korhonen et al., 2003; Warburton and Mason, 2006, p. 77) and a physiological parameter (cortisol in Mason et al., 2001; Korhonen et al., 2003).

4) Addressing rewarding properties in consumer-demand tests: mink work hard for access to a swimming bath and running wheel. The properties of other cage enrichments (e.g. tunnels, biting objects), however, should not be neglected if they are provided under otherwise poor conditions, and because they may satisfy other motivational aspects of mink.

5) Individual differences in the appraisal for swimming water clearly exist: eventually due to prior experience or elicited by so far unknown cues. In this case, the resource should be considered as more or less important for a particular individual.

6) Swimming water seems not an "innate" or biological need in the sense of absolute distinction between "need" or "no need". It is most likely that swimming water is an incentive that induces its own motivation ("incentive induced need").

In general, the provision of cage enrichments for farmed mink should be focussed on variability and choices (see Hansen et al., 2007). Pragmatically it should be considered to focus more on relevant alternative cage enrichments with a potential to improve minks' welfare, as these are much easier to apply in practice than swimming water. The following topics might be of interest for future studies: detection if particular cues in mink farming practice may elicit mink's motivation to swim (e.g. drink water delivery systems) and the effects of prior experience with the incentive ("can you miss what you never experienced?"). Furthermore, more attention should be paid on the parameter ''stereotypy'', at least studies should address the following topics: 1) the level of stereotypies in their experimental populations at the start of the study, but preferably one should start with a non-stereotyping population; 2) attention should be paid to give insight into winter food regimes and their interfering influence on the results: e.g. correlations with body weights and applying *ad libitum* regimes during the studies.

May other areas of interest as they were less presented in the available studies or only one study addressed this topic, are: rebound effects and vacuum activities (which could not be shown in the present studies), preferences for and the value of alternative resources, substitutability of alternative resources, ‘positive indicators’ of welfare (i.e. play behaviour, anticipatory behaviour), the effects of preventing the performance of rewarding behaviours (deprivation of a previous experienced resource) and the hygiene of a water bath. Surplus values on information in future papers would be the actual percentages of animals using a water bath during the experiment and the use of power analyses.

Acknowledgements

We are grateful for the establishment of the Fur Animal Welfare Research Committee (FAWRC) as recommended by the Council of Europe. The studies were conducted under the supervision of the FAWRC and made possible with financial support from the European Fur Breeders' Association (EFBA) and the International Fur Trade Federation (IFTF).

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Table 1.

Overview of some quality parameters in different studies addressing minks' appraisal for water baths.

Table 2.

Overview of the power of some studies addressing minks' appraisal for water baths.